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Reinterpreting Change in Traditional Ecological Knowledge

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Much research on traditional ecological knowledge (hereafter TEK) has centred in 1) documenting fading knowledge (e.g., Ferguson and Messier 1997; Pieroni *et al.* 2004), 2) understanding the parallel changes in biological and cultural diversity (Maffi 2005; Harmon and Loh 2010), and 3) assessing the processes and drivers of change that lead to the loss of TEK (Benz *et al.* 2000; Kingsbury 2001; Godoy *et al.* 2005; Gray *et al.* 2008; Turner and Turner 2008; Gómez-Baggethun 2009). The general argumentative thrust is to lament the loss of TEK among indigenous peoples and rural communities. For example, in the last decade a growing number of studies have reported changes and losses in the medicinal (Begossi *et al.* 2002; Case *et al.* 2005; Lozada *et al.* 2006; Monteiro *et al.* 2006), nutritional (Turner and Turner 2008), and agricultural (Benz *et al.* 2007; Stone 2007; Gómez-Baggethun *et al.* 2010) knowledge of small-scale societies as they become more integrated in national societies and the market economy.

The idea that TEK systems are capable of adapting both to external changes and internal pressures has been a mainstay of human ecology for some time (e.g., Berkes *et al.* 2000). Yet by analyzing change primarily in terms of lost knowledge the usual research perspective tends to downplay the dynamic nature of TEK systems, and little emphasis is put in understanding particular changes in TEK as an adaptive response to new environmental, social, or economic conditions. Likewise, few researchers have examined how the causes of the loss of TEK (i.e., modernization, technology, schooling, or integration into the market economy to name the most commonly mentioned factors) actually affect the mechanisms that allow societies to generate, regenerate, transmit, and apply knowledge. Consequently our understanding of how these processes affect the resilience of TEK systems and their capacity to evolve and adapt is still limited.

In this paper we analyze some factors and conditions that maintain or undermine people's ability to adapt and regenerate TEK in the face of changing environmental and socioeconomic conditions. We attempt to thereby understand the factors underlying the loss of TEK and the mechanisms used by societies to regenerate and transmit such knowledge in the face of environmental change.

Changes in Traditional Ecological Knowledge Systems

Our research is based on two case studies reporting changes in TEK systems. The first case study centers on the Tsimane', a hunter–horticulturalist society in the Bolivian Amazon, which—according to previous published research—, seems to maintain the capacity to generate and apply TEK. The second case study centers on farmers of the Doñana region in southwest Spain, where rural communities have suffered a disruption in the process of intergenerational transmission of TEK as their agricultural systems modernized and integrated the global markets in the mid twentieth century.

Case Study 1: Traditional Ecological Knowledge Among the Tsimane', Bolivia

A great deal is known about the Tsimane' in general, as they have received considerable attention from cultural and physical anthropologists (Chicchon 1992; Ellis 1996; Daillant 2003; McDade *et al.* 2007; Huanca 2008; Ringhofer 2010). Until the late 1940s, most Tsimane' lived isolated from the outside world. They hunted, fished, gathered wild plants, and practiced slash-and-burn agriculture for subsistence. Their relative isolation ended in the 1950s. Construction of new roads, arrival of missionaries and highland colonist

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farmers, schooling, and the logging boom, put Tsimane' in contact with Bolivian society, a process that gradually transformed their social and economic system (Chicchon 1992; Godoy *et al.* 2005). These changes brought modern ways of living and a new social environment that gradually encroached upon their society. Nowadays some Tsimane' are highly self-sufficient, but others are increasingly adopting market-based economic activities such as cash cropping or the sale of forest products in markets (Vadez *et al.* 2008).

Previous research on Tsimane' TEK relates individual levels of TEK being associated with effective habitat management proxied by the conservation of crop diversity (Reyes-Garcia *et al.* 2008b) and with the reduction of the area of old-growth forest cleared for slash-and-burn agriculture (Reyes-Garcia *et al.* 2007b). We have also found a positive association between individual levels of TEK and nutritional status (Reyes-Garcia *et al.* 2008a) and offspring's health (McDade *et al.* 2007).

Also analyzing cross-sectional data from Tsimane' adults, Godoy *et al.* (2009) see no evidence of secular loss of knowledge since the 1920s although the data seem to suggest a net decrease in the report of plant uses (Reyes-García *et al.* 2013). A more fine-grained analysis using domains of knowledge is able to reconcile those two findings, as it seems that different domains of plant knowledge follow different secular trends. For example, the Tsimane' seem to be losing knowledge related to wild edible and medicinal plants, although they seem to be generating new knowledge on the domain of plants used for house building. Increasing sedentarization pushes the Tsimane' to build larger and more durable houses. Also we found that people who are relatively isolated from the market economy share more TEK than people who live in villages closer to towns (Reyes-Garcia *et al.* 2005). Among the Tsimane' only those market related activities that take people out of their immediate habitat and cultural context have a negative effect on their TEK (Reyes-Garcia *et al.* 2007a). This highlights the importance of contextual social transmission of knowledge.

Although we found that schooling bears the expected negative association with TEK, the magnitude of the association was surprisingly low, challenging results of previous research in similar contexts (Benz *et al.* 2000; Sternberg *et al.* 2001). Formal schooling was introduced in the area several decades ago by Protestant missionaries. Missionaries provided a partially contextualized school curriculum (i.e., in Tsimane' language, using examples from the local environment, with Tsimane' teachers) that did not seem to interfere with the transmission of TEK as much as do other types of schooling (Reyes-Garcia *et al.* 2010).

In sum, our previous research among the Tsimane' documents different patterns of secular change: some domains of knowledge are decreasing, some remain stable, and some are increasing.

Case Study 2: Traditional Ecological Knowledge Among Farmers of Doñana, Spain

Farmers of the Doñana natural areas (southwest Spain) are much affected by processes of market integration and acculturation. Until about the middle twentieth century, Doñana maintained a semi-autarchic and subsistence-oriented economy with strong dependence on local ecosystem services (Ojeda 1987). Failures to adapt in the face of severe drought and other environmental extremes typically resulted in economic crises and famines (Flores 2005; Gómez-Baggethun *et al.* 2010). A variety of locally-evolved adaptive practices (e.g., mobility, pooling, diversification, storage, rationing) and rituals (e.g., rogation ceremonies) formed part of the communities' mechanisms to cope with environmental variability and change (Gómez-Baggethun *et al.* 2012).

Since the early nineteenth century, enclosure of common lands and other institutional changes that followed liberal revolutions in Spain paved the way for modernization, development of productive forces, and market integration (Naredo 2004), but TEK continued to play an important role in resource management by local farmers (Ojeda 1987). In the 1960s, exogenously driven development and conservation policies radically transformed resource systems in Doñana, resulting in a sharp decline in associated bodies of TEK (Estevez and Rosell 1989). In our previous research, we found that intergenerational decline in TEK (proxied through a sample of adaptive practices to cope with disturbance and change) was most acute in agricultural knowledge, finding a decline of about 40 % between the old and young age classes, but less pronounced for traditional livestock farming, which declined by 16.5 % between the old and middle age classes and by 5.65 % between the middle and young age classes (Gómez-Baggethun *et al.* 2010).

We identified three main drivers behind the loss of TEK: market integration, conservation policies, and acculturation. First, market integration in the 1960s was accompanied by fast mechanization and intensification of resource systems. Many farmers abandoned traditional agriculture—mainly consisting of vines, olive groves, and cereal—and engaged in new agricultural systems demanding large inputs of energy, machinery, fertilizers, and pesticides (González-Arteaga 1993). New crops (e.g., strawberry) adopted in this period required management techniques that were unfamiliar to local farmers (Corominas 1995).

Second, top-down implementation of the Doñana National Park in 1969 with a 'fortress conservation' approach excluded local resource users largely from ecosystem management in the protected areas. Consequently, scientific knowledge progressively substituted TEK (Gómez-Baggethun *et al.* 2010).

Historically, local religious beliefs had played a central role in representing and responding to environmental change (Gómez-Baggethun *et al.* 2012). At least since the fifteenth

century the locals organized rogation ceremonies to secure protection against environmental hazards such as droughts, pests, and floods (Flores 2005). By promoting community cohesion and representing the sources of hardship as being external to socioeconomic relations, rogation ceremonies seemingly reduced the likelihood of social disruption, thereby enhancing the resilience of the community to cope with crises (Gómez-Baggethun *et al.* 2012).

In the twentieth century, the scientific understanding of environmental extremes marked a transition in the strategy used in response to environmental change, whereby responses that relied heavily on TEK where progressively replaced by responses based on technological fixes. For example, the possibility of pumping underground water through imported technology alleviated (but also masked) the impacts of drought (González-Arteaga 1993). In 1956 rogation ceremonies were regularized so as to be held every 7 years thereby being uncoupled from environmental hazards. In sum, there was a secular loss of TEK associated with processes of market integration, conservation policies, and acculturation.

Discussion

The two case studies show that TEK systems held by small-scale societies can respond very differently to the forces of globalization. This explains why while some TEK systems manage to adapt and regenerate others fail to do so. Our research suggests that, for the Tsimane', TEK 1) continues to be at the basis of livelihood, and it is associated to different health, economic, and environmental outcomes, 2) shows dissimilar secular trends across different domains of knowledge and occupations, and 3) is only partially affected by the processes of exposure to the market economy and schooling. Those results challenge the assumption that TEK should irremediably fade as indigenous people increase their interactions with national societies and the market economy. In the 1950s the Tsimane' started experiencing profound societal and economic changes. But despite those deep changes around and within their society, the Tsimane' still continued to greatly depend on the forest around their villages for their livelihood. Nowadays, most Tsimane' are only partially more reliant on products generated outside their own society than they were some decades ago. Furthermore, the social and environmental context that allow for the maintenance and production of TEK still remains in place. For example, Tsimane' mostly have social interactions with other Tsimane', and exogamy is extremely unusual (Daillant 2003).

Because the Tsimane' continue to rely on their TEK for their livelihood in a delineated localized cultural and environmental manner it is not surprising that we find evidence for the adaptation of Tsimane' TEK system: particular bodies of knowledge that are less used (i.e., wild edibles) are decreasing, knowledge in some other domains (i.e., house building) is increasing. The finding suggests that the ability of the system to generate new knowledge remains as the social and environmental circumstances in which Tsimane' live change, even if knowledge in certain domains is lost.

Tsimane' relation with and dependence on their immediate habitat, helps explain adaptation and change of their TEK. Because the Tsimane' continue to use local resources for their subsistence, they still seem to retain the ability to generate, transmit, and discard knowledge according to their particular needs. Thus, the Tsimane case study reflects how the adaptive capacity of TEK is more likely to be maintained when it remains in people's control.

Our Doñana research suggests that TEK 1) has been progressively replaced by scientific and technical knowledge, 2) shows dissimilar secular trends across different domains of knowledge, and 3) has been affected by mechanization and exposure to the market economy.

Thus, while the Tsimane' continued to sell products that they produce in 'traditional ways', TEK-driven resource systems in Doñana no longer secured the productivity and profit margins required to compete in the international market. Comparative advantages of TEK-driven resource systems such as their low impacts on soils, water, and biodiversity (and thereby their capacity to maintain long term ecological resilience) became less important in the emerging mode of production, where profits depend to a large extent on the ability to externalize environmental impacts from production costs (Naredo 2003). Similarly, the ability of TEK-driven resource systems to adapt in the face of environmental variability (Berkes *et al.* 2000) became less important as human-made capital buffered its direct impact on production. For example, as we noted in a previous article 'the use of pesticides and fertilizers discouraged traditional practices formerly employed to prevent pest outbreaks and oxygenate the soil, while the possibility of pumping underground water discouraged the selection of drought-adapted species and diversification of crops to buffer droughts' (Gómez-Baggethun *et al.* 2010: 727). Adoption of modern technologies in scientifically rationalized production systems reduced the reliance of local farmers on TEK, making them more dependent on exogenously produced technology and technical expertise and knowledge.

Also conservation policies implemented in Doñana conflicted with customary TEK. Unlike the Tsimane', who maintained sovereignty over their resources, in Doñana, enclosures and banning of traditional management practices for conservation purposes (e.g., use of fire) prevented local communities from experimenting with their TEK in the protected areas,

In sum our results support the hypothesis that industrialization of agriculture and conservation policies that exclude local

farmers from management favors a process of deskilling that precludes TEK from adjusting to the new socioeconomic conditions.

Conclusion

The fact that a specific unit of knowledge is lost or kept by a society is not as important as whether the society retains the ability to generate, transform, transmit, and apply knowledge. It is the capacity to generate and apply knowledge that enables actions and adjustments in response to current and future changes, and therefore it is the capacity to generate and apply knowledge—and not the knowledge itself—that contributes to increase the resilience of a socio-ecological system. Maintaining the capacity to regenerate TEK over time requires the on-going developing, testing, and updating of knowledge. While location and context are important factors that show the need for further inquiry, our research suggests that maintaining conditions for TEK regeneration requires holding sufficient levels of sovereignty over land, ecological means of production, technology, and livelihood related knowledge systems.

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